

## **APPLICATION OF GPS TECHNOLOGY (GLOBAL POSITIONING SYSTEM) IN FOREST INVENTORY STATISTICS**

**FLORIN DORIAN COJOACĂ<sup>1</sup>, FLORIN ACHIM<sup>2</sup>, MARIAN STAN<sup>2</sup>, SILVIU PĂUNESCU<sup>2</sup>**

<sup>1</sup>*Faculty of Agriculture and Horticulture of the University of Craiova,  
E-mail: f\_cojoaca@yahoo.com*

<sup>2</sup>*Forest Research and Management Institute Bucuresti*

**Keywords:** *GPS, inventory statistics, georeferencing, sample surface*

### **ABSTRACT**

This paper presents a methodology based on the use of GPS technology to identify network sample areas for statistical inventory stands, purposes.

The proposed method facilitates the designer's work on the sample location and materialization, working time is reduced significantly because it is no longer necessary to measure distances between sample plots, and the field orientation is much easier and avoids the subjectivity in establishing the centers of sample areas, meaning their quadratic grid.

Therefore, using GPS technology in sample surfaces location brings clear improvements to that one presently used for the statistical inventory works of exploitable stands (both for the precision and the duration of execution), so that its practical application is not only useful, but even recommended.

### **1. INTRODUCTION**

Forest inventory requires knowledge of the structure, volume, growth and quality after previously were determined dendrometrical characteristics of components stands.

Forest inventory purpose is to regulate the production process, but also to make a control of the growing stock, including its evolution under the management of applied measures (Alexe, Milescu, 1983).

Presently, according to technical standards profile (xxx, 1986, xxx, 2000) of forest planning, dendrometrical characteristics are mainly established through partial inventory (statistical) and in individual cases through complete inventory (Giurgiu, 1979 Leahu 1994).

The forest inventory methodology is clearly defined by forest planning tutorials (xxx, 1984), but the practice has shown that the location and materialization of the sample areas (sample plots) is laborious, time and resources consuming, and often errors generating.

This methodology (process) – in case of partial inventories - can be improved by application of GPS technology, particularly in location and materialization of the network sample areas.

### **2. SCOPE AND OBJECTIVES**

The main purpose of this paper is to establish a methodology (process) to identify and place the sample plots (sample area) within the stands using the GPS technology.

Starting with this point of view, it was took into consideration to formulate practical advices to be incorporated in forest planning normative, applicable in statistical inventory of the exploitable stands.

### 3. RESULTS AND DISCUSSIONS

#### 3.1. GPS technology necessity in sample plots placement, for statistical stands inventory

Due to the fact that the actual used technology (of 30 years old) is obsolete, we would like to propose a new and easier methodology, using GPS technology, that gives greater accuracy in quadric grid designing and sample areas identifying.

In this regard the plot / subplot limits together with their quadric grid location could be drawn with CAD family<sup>1</sup> programs (e.g. *AutoCAD*).

From working CAD on GPS devices the files are exported in various formats (.*geotiff*, .*kml*/.*kmz* etc.). Using these devices, there are identified the plots center, in field, after a prior theoretical location establishment.

Using GPS technology gives more accuracy in quadric grid location for the sample plots needed for the stands inventory, compared with the classic method involving the conversion of the distance between sample plots, in paces ( taking into consideration the standard pace of the worker), according with the correction coefficients for slopes.

#### 3.2. Scanning the cartographic material

In a first phase, cartographic material (basic topographic plans or forest planning maps) is scanned - using a mapping scanner of A0 + - in TIFF (tagged image file format) making digital images (raster) (fig. 1).



**Fig. 1 Scanning basic topographical plan**

---

<sup>1</sup> *computer-aided design*

### 3.3. Calculation of the trapeze corners coordinated and theirs automatic generating

To calculate the corners coordinates of trapeze and its generating, it can be used in the working space of AutoCAD software that automatically calculates and draws trapezoidal sheet according the trapeze nomenclature (Figures 2,3).

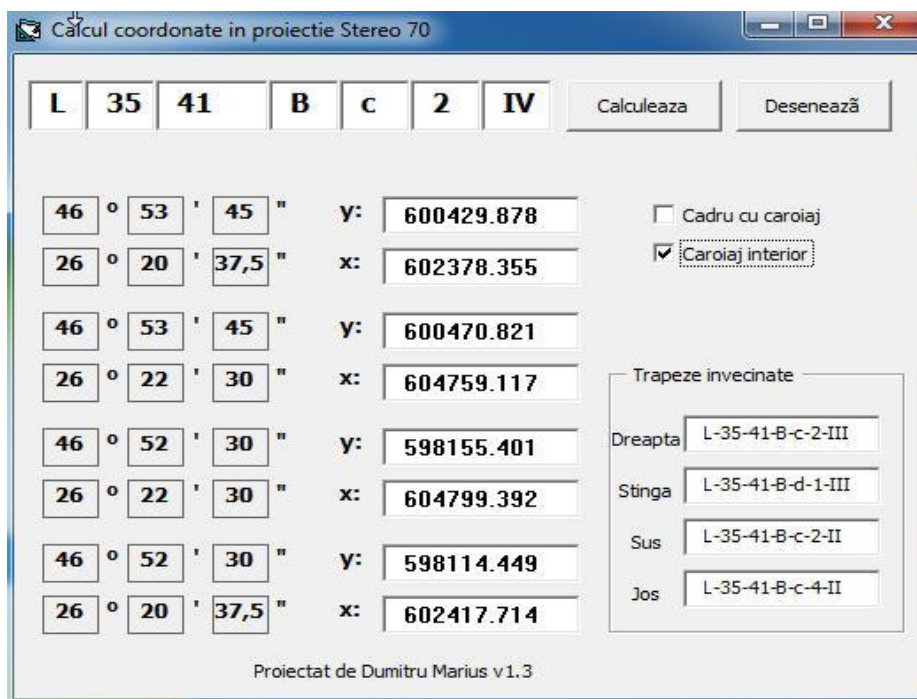


Figure 2 Automatic calculation of the trapeze corners coordinates

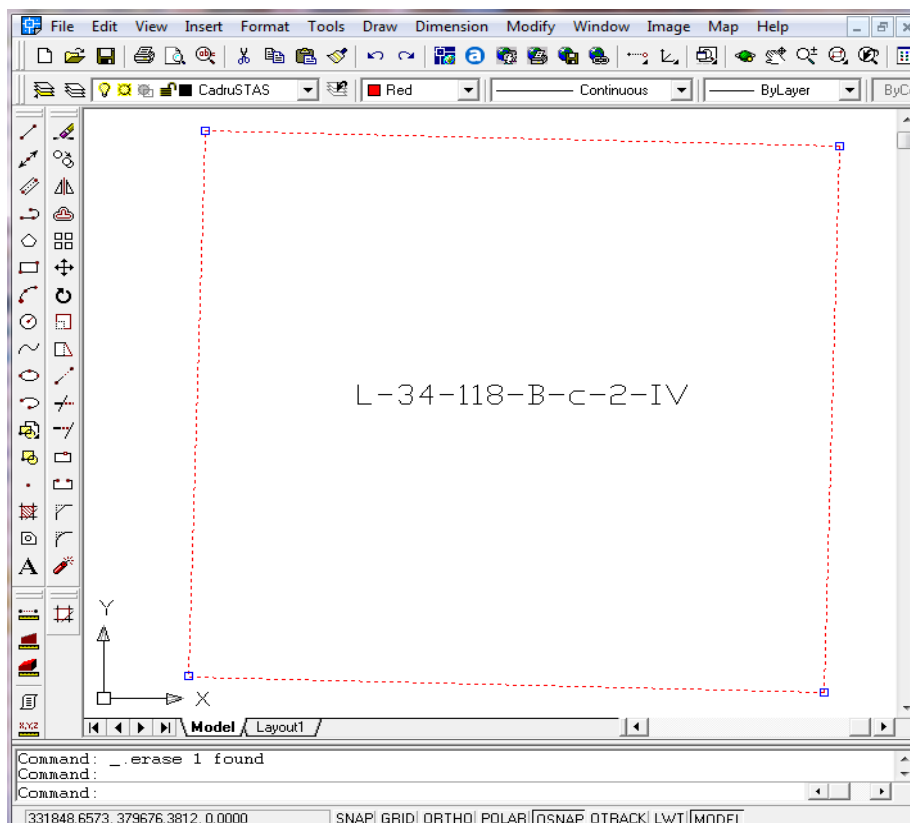
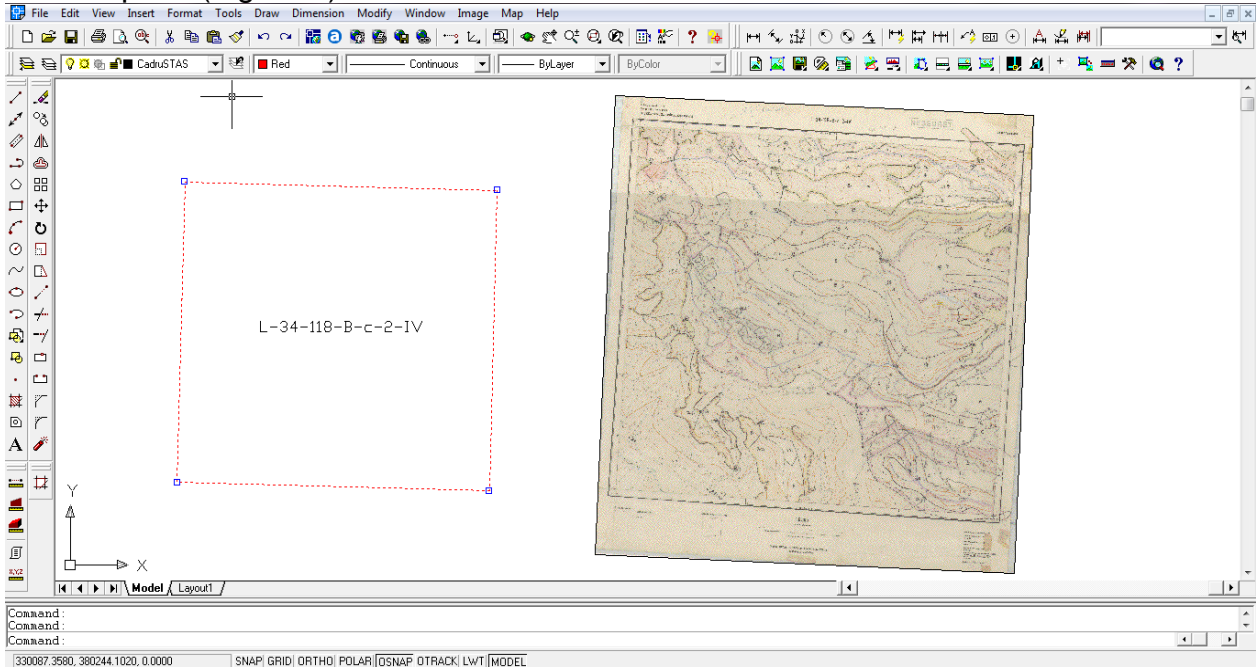


Figure 3 Automatic generating of trapeze sheet according to its nomenclature

### 3.4. Georeferencing the topographic basic plan

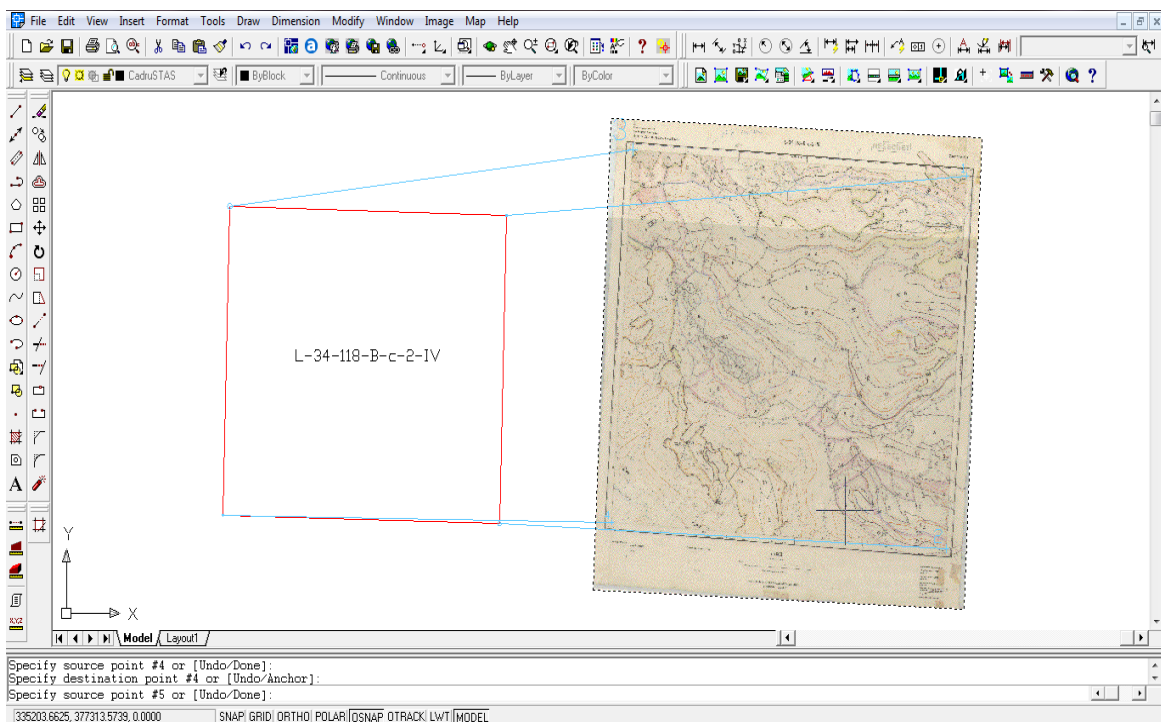
Using specialized software (eg Global Mapper, ESRI ArcGIS, Autodesk Map) the scanned digital images are positioned in a fixed coordinate system, by georeference.

First of all the image of prior scanned is inserted in AutoCAD software close to the drawn trapeze (Figure 4).

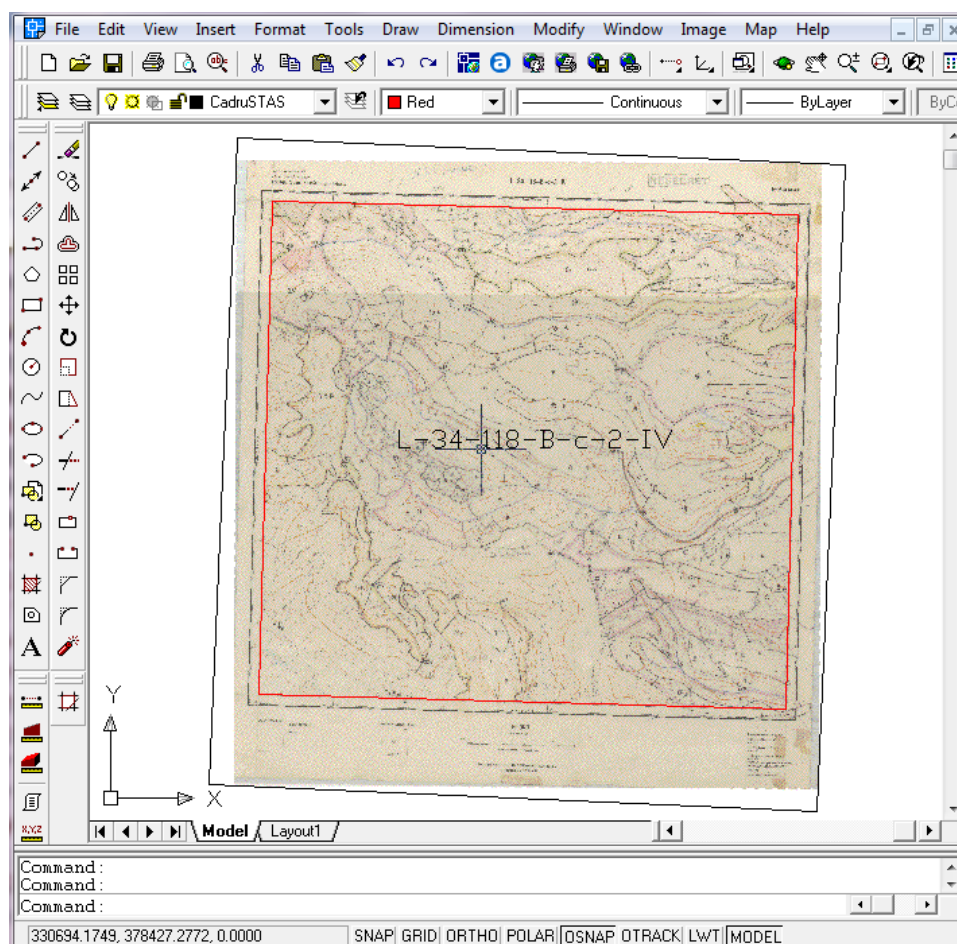


**Figure 4** Inserting scanned image of topographic basic plan

Using the *Rubbersheet* function within the software (meaning - AutoCAD), the corners of the scanned plan overlap over the corners of the trapeze sheet automatically generated (Figure 5), resulting in this way the georeferenced basic plan (Figure 6) for standard system (eg Stereo 70).



**Figure 5** Overlapping corners the scanned topographical plan over trapeze generated sheet



**Figure 6 Basic topographic georeferenced plan**

Therefore, the basic topographic plan with its set coordinates by the georeference, achieving in the same time even a post-scanning plan correction, because of the eventual errors due to scanning process or scanner device. It is compulsory that the average of the squared error occurring after transformation is not greater than the admitted error of the topographic plan or the initial map (Seceleanu et.al., 2008).

Hereafter, the raster is exported in a standard format "GeoTIFF world file type". This file type contains a \*.tif file and a \*.tfw file attached to each raster (eg L-34-118-B-c-2-IV.tif and L-34-118-B-c-2-IV.tfw).

### **3.5. Vectorization of inventory plot / subplot contour**

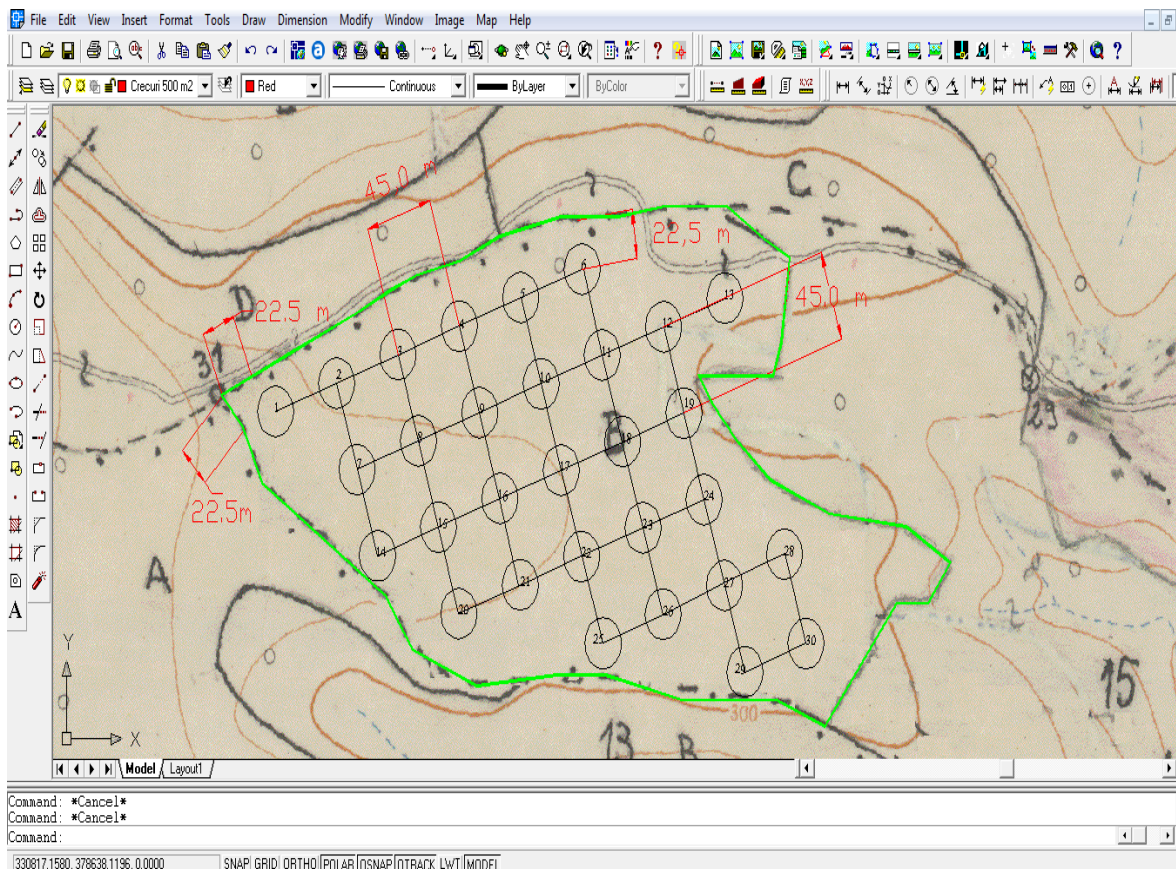
Following the basic plan georeferencing, starts the vectorization of the inventory plot / subplot limits, and the quadric grid that shows the location of sample plots, is implemented within the frame of inventory plot/subplot ( according with the Forest Planning Guide) (Figure 7).

### **3.6. Exporting data (vector or raster)**

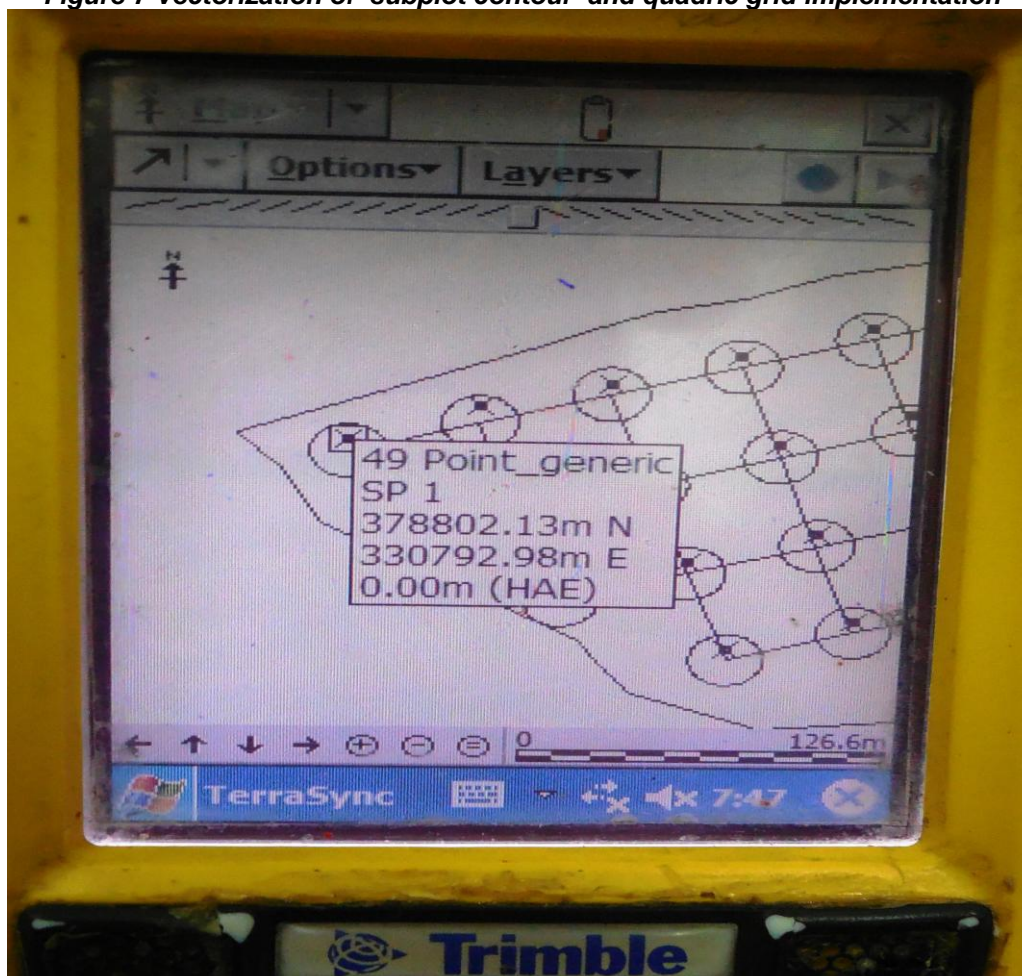
Once you have mapped the limits of compartment and where were placed the sample points through the areas sample centers, these ones will be exported to a GPS device in a .kml/KMZ, .geotiff, .gpx etc. type extension.

### **3.7 Identifying the sample points within the sample area**

Having the plot / subplot drawing loaded in GPS device, the operator is going on the sample area to identify the compartment, where it is performed the statistical inventory, and the center of each sample point (Figure 8).



**Figure 7** Vectorization of subplot contour and quadric grid implementation



**Figure 8** Identifying the sample centre with GPS receiver

#### 4. CONCLUSIONS

Considering all data presented it shows the new superior method to locate the circular sample areas network necessary for the statistical forest inventory activity.

Therefore, using GPS technology to sample plots location has several advantages compared with the traditional method, as it follows:

- facilitates designer's work in locating and implementing the sample plots;
- returning back in same sample point using its coordinates, occasioned by the verification and acceptance of inventory works for exploitable stands; furthermore, in case of exploitable stands of selection forest, the new method is even more appropriate, because the inventories are performed within the permanent sample areas, and for the futures planning activities, the returning back to the centers of the sample plots, is easy and precise;
- working time is significantly reduced, because it is no longer necessary to measure distances between sample plots;
- position finding is much easier and ensures the exact identification of plot/subplot were works are performed;
- increase the works precision through systematic implementation of the systematic squares network previously drawn on PC, avoiding in this way the operator subjectivity when are set the centers of sample circles;
- it can easily to find if there are differences between the shape and compartment area from field and that one drawn on basic plan. This fact can be corrected by overlapping the compartment on basic plan, returning back to this one, after a new drawing of the quadric square, according to the new shape and size of subplot surface.

Consequently, the methodology described in this paper, which is obviously superior than conventional currently used method, it is recommended to be incorporated into „Guidelines for forest planning“ and applied to sample plots placement for the statistical stands inventory.

#### 5. REFERENCES

**Alexe, A., Milescu, I., 1983** - Inventory of forests. Ceres Publishing House, Bucharest;

**Giurgiu, V., 1979** - Dendrometry and auxology in forestry. Ceres Publishing House, Bucharest;

**Leahu, I., 1994** - Dendrometry. Didactic and Pedagogic Publishing House, Bucharest;

**Seceleanu, I. et al, 2008** - Getting geographical databases and developing thematic maps in GIS. *Handbook concerning the methodology for long-term monitoring of forest ecosystems under the air Pollution and climate change modification*. Badea, O. (editor), Silivică Publishing House, Bucharest: 83-98;

\*\*\*, **1984** - Guidelines for Forest Planning, vol. I, II, ICAS Bucharest.

\*\*\*, **1986** - Technical Standards for Forest Planning no. 5, the Ministry of Forestry.

\*\*\*, **2000** - Technical Standards for Forest Planning no. 5 M.A.P.P.M.